Inspecting the Mechanism:

Leverage and the Great Recession in the Eurozone*

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PRELIMINARY and INCOMPLETE

Abstract

Economists disagree widely about the nature of the Eurozone crisis. Some see the crisis as driven by fiscal indiscipline, others by external imbalances and sudden stops, others by excessive private leverage. Motivated by the comparison of the Great Recessions in the U.S. and the Eurozone, we analyze the role of private and public leverage and ask: (i) What are the main drivers of the recession? (ii) To what extent can private and public leverage movements explain macroeconomic outcomes in the different Eurozone countries? (iii) What are the respective roles of sudden stops of foreign capital and fiscal policies? We present a model of open economies within a monetary union where macroeconomic dynamics are driven by private and public leverage decisions. We decompose the role of these various factors in the building up of macro-imbalances during the boom as well as the dynamics of each country during the crisis and analyze how our model can explain the cross-sectional variance in employment, output and consumption in the Eurozone countries. We find that, from 2008 to 2012, the difference in fate across Eurozone countries is well explained by the dynamics of household leverage during the boom. The mechanisms at work in the Eurozone are similar to those of the U.S. We also show that fiscal policy is an important determinant to explain how the different economies performed during the recession. After 2010, however, we find a distinct role for sudden stops and sovereign risk in the Eurozone, but not in the United States.

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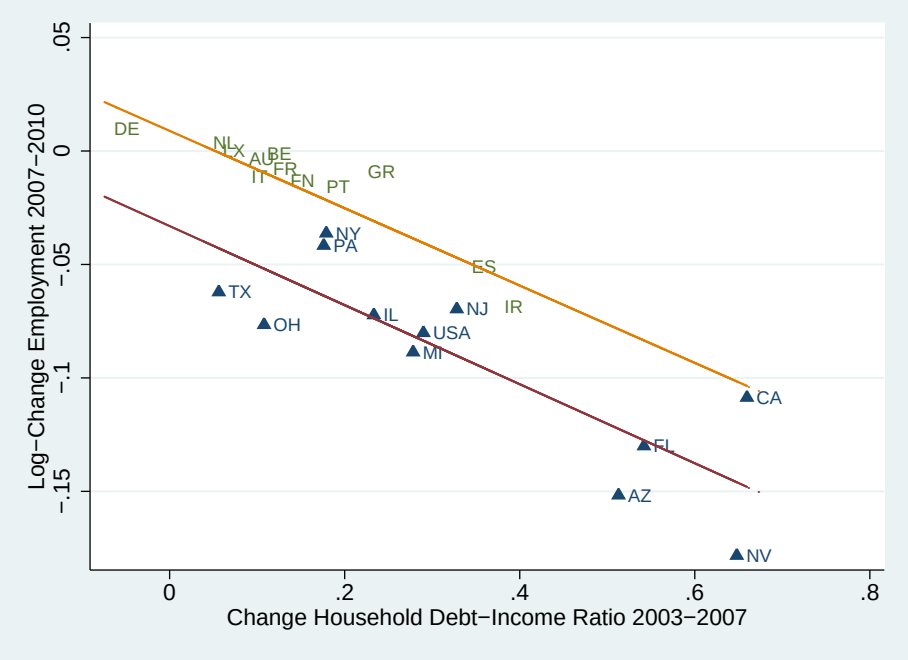
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Introduction

A striking feature of the European crisis is the lack of consensus about its causes, even among economists who normally share a common analytical framework. Economists profoundly disagree about causes and solutions. Some see the crisis as driven by fiscal indiscipline, others by external imbalances and sudden stops, others by private deleveraging.[1]

A salient feature of the great recession is that regions that have experienced the largest swings in household borrowing have also experienced the largest declines in employment and output. Figure 1 illustrates this feature of the data, by plotting the change in employment during the credit crunch (2007-2010) against the change in household debt-to-income ratios during the preceding boom (2003-2007) for US states[2] and Eurozone countries.

Figure 1: First Stage of the Great Recession: Household Borrowing predicts Employment Bust



The American and European cross-sectional experiences look strikingly similar in this respect on the period 2007-2010. This suggests that the shock faced by these two economies were similar in nature. Moreover this suggests that the structural parameters that govern the way the economy reacts to a deleveraging shock may also be similar in the two monetary zones. As noted in Midrigan and Philippon (2010), this pattern is at

[1] In addition, there is disagreement about the role of multiple equilibria but this is not our focus here.

[2] State level household debt for the US comes from the Federal Reserve Bank of New York, see Midrigan and Philippon (2010).

odds with the predictions of standard models of financing frictions. Such models predict that a tightening of borrowing constraints at the household level leads to a decline in consumption but, due to wealth effects, to an increase in the supply of labor. In this paper, we analyze a model where borrowing limits on "impatient" agents drive consumption, income, the saving decisions of "patient" agents and employment in small open economies belonging to a monetary union. We show that such a model with a first stage of leveraging up of "impatient" agents and then deleveraging can broadly reproduce what was observed across Eurozone countries during the recession starting in 2008 for employment, nominal GDP, consumption and wages. The nominal credit shock starting in 2008 generates a decline in borrowing thus leading to a fall in consumption spending and nominal income. "Patient" agents are affected because of the nominal income fall and reduce their saving as a consequence of the shock. We show that this crucially depends on the share of patient agents, on the openness of the economy and also on the reaction of the government. We indeed show that if the government can increase public nominal debt in reaction to the private credit shock, it can stabilize the economy. We introduce nominal wage rigidities which translate the decline of nominal expenditures into employment.

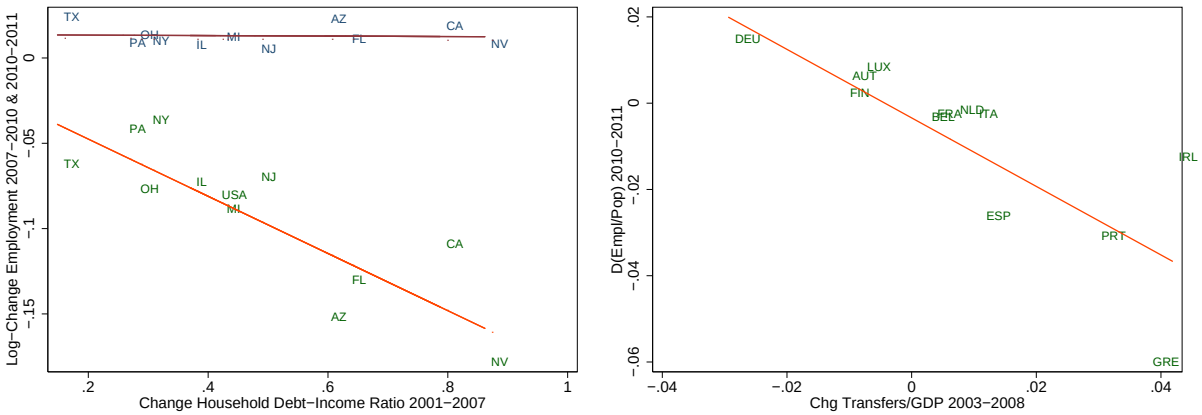
Figure 2 illustrates the differences between the American and European experiences during the later stage of the recession. Starting in the Spring of 2010, sovereign spreads widen and several European countries find it difficult to borrow on financial markets. The US and EZ experiences then start to diverge. While US states grow (slowly) together, EZ countries experience drastically different growth rates and employment. But the state variable that correlates with labor markets performance in 2010-2011 in the Eurozone is not household leverage anymore, it is social transfers during the boom. EZ countries where spending on transfers increased the most from 2003 to 2008 are the ones that are now experiencing severe recessions in the last stage.

We present a simple model that can shed light on the mechanisms at work in a monetary union and where we concentrate on the impact of private leverage, fiscal policy and sudden stops. Our model allows us to decompose the role of these various factors in the building up of macro-imbalances during the boom as well as the dynamics of each country during the crisis.

Relation to the literature

Our paper is related to three lines of research: (i) macroeconomic models with credit frictions, (ii) monetary economics, (iii) sovereign debt and fiscal policy. We discuss the connections of our paper to each topic. Following Bernanke and Gertler (1989), many macroeconomic papers introduce credit constraints at the entrepreneur level (Kiyotaki and Moore (1997), Bernanke et al. (1999), or Cooley et al. (2004)). In all

Figure 2: Second stage:



these models, the availability of credit limits *corporate* investment. As a result, credit constraints affect the economy by affecting the size of the capital stock. Curdia and Woodford (2010) analyze the implication for monetary policy of imperfect intermediation between borrowers and lenders. Gertler and Kiyotaki (2010) study a model where shocks that hit the financial intermediation sector lead to tighter borrowing constraints for entrepreneurs. We model shocks in a similar way. The difference is that our borrowers are households, not entrepreneurs, and, we argue, this makes a difference for the model's cross-sectional implications. Models that emphasize firm-level frictions cannot reproduce the strong correlation between household-leverage and employment at the micro-level, unless the banking sector is island-specific, as in the small open economy "Sudden Stop" literature (Chari et al. (2005), Mendoza (2010)). This "local lending channel" does not appear to be operative across U.S. states, however, presumably because business lending is not very localized.[3] In the eurozone, financial integration has also - until the most recent crisis - led to large cross-border lending. Most closely connected to our paper is the work of Midrigan and Philippon (2010), Guerrieri and Lorenzoni (2010) and Eggertsson and Krugman (2012) who also study the responses of an economy to a household-level credit crunch. Consistent with our results, Sufi and Mian (2012) show that differences in the debt overhang of households across U.S. counties partly explain why unemployment is higher in some regions than others. Schmitt-Grohe and Uribe (2012) emphasize the role of downward wage rigidity in the Eurozone recession. Our paper is also related to the literature on sovereign default (see Eaton and Gersovitz (1982), Arellano (2008) and Mendoza and Yue (2012)) that models default as a strategic decision with a tradeoff between gains from forgone repayment and the costs of exclusion from international credit markets. The objective

[3]For instance, Mian and Sufi (2010) find that the predictive power of household borrowing remains the same in counties dominated by national banks. It is also well known that businesses entered the recession with historically strong balanced sheets and were able to draw on existing credit lines Ivashina and Scharfstein (2008).

of our paper however is to analyze how the sovereign default risk can affect the real economy through the impact it can have on liquidity available to households. The paper by Corsetti et al. (2011) considers a "sovereign risk channel," through which sovereign default risk spills over to the rest of the economy, raising funding costs in the private sector.

In Section 1 we present the model. In 2, we conduct a series of quantitative experiments with leverage dynamics, fiscal policy and sudden stops. Section 3 concludes.

1 Model

Our model can be interpreted as a large country with a collection of regions (e.g., USA), or a monetary union with a collection of states (e.g., EZ). The key assumption are that these regions share a common currency, and that agents live and work in only one region.

We consider an open economy that trades with other regions of the currency area. Each region$j$ produces a tradable domestic good and is populated by households who consume the domestic good and an aggregate of foreign goods. Following Mankiw (2000) and more recently Eggertsson and Krugman (2012), we assume that households are heterogenous in their degree of time preferences. More precisely, in region j, there is a fraction χ_j of impatient households, and $1-\chi_j$ of patient ones. Patient households (indexed by s for savers) have a higher discount factor than borrowers (indexed by b for borrowers): $\beta \equiv \beta_s > \beta_b$. Saving and borrowing are in units of the currency of the monetary union.

1.1 Set-up

Within period trade and production. Consider household $i = s, b$ in region j at time t. Within period, all households have the same log preferences over the consumption of home (h) and foreign goods (f), and labor supply n:

$$u_{i,j,t} = \alpha_j \log\left(\frac{c^h_{j,t}}{\alpha_j}\right) + (1-\alpha_j)\log\left(\frac{c^f_{j,t}}{1-\alpha_j}\right) - \nu\left(n_{i,j,t}\right)$$

With these preferences, households of region j spend a fraction α_j of their income on home goods, and $1-\alpha_j$ on foreign goods. The can be interpreted as the home bias and more generally we will think of α_j as

measuring how closed the economy is. The demand functions are:

$$\begin{aligned} p_{j,t}^h c_{i,j,t}^h &= \alpha_j x_{i,j,t}, \\ p_t^f c_{i,j,t}^f &= (1-\alpha_j)\, x_{i,j,t}. \end{aligned}$$

where $x_{i,j,t} = p_{j,t}^h c_{i,j,t}^h + p_t^f c_{i,j,t}^f$ is spending of type $i = s, b$ in region j in period t, $p_{j,t}^h$ is the price of home goods in country j and p_t^f is the price of foreign goods. This gives the indirect utility

$$U\left(x_{i,j,t}, p_{ijt}\right) = \log\left(x_{i,j,t}\right) - \log \bar{p}_{j,t} - \nu\left(n_{i,j,t}\right),$$

where the CPI of country j is $\log \bar{p}_{j,t} = \alpha \log p_{j,t}^h - (1-\alpha_j) \log p_{j,t}^f$, the PPI is $p_{j,t}^h$, and the terms of trade are $\frac{p_t^f}{p_{j,t}^h}$. Foreign demand for home good is assumed to have unit elasticity $\bar{x}_f / p_{j,t}^h$. Production is linear in labor, equal to employment $n_{j,t}$, and competitive, so $p_{j,t}^h = w_{j,t}$. Market clearing requires:

$$n_{jt} = (1-\chi_j)\, c_{s,j,t}^h + \chi_j c_{b,j,t}^h + \frac{\bar{x}_f}{p_{j,t}^h} + g_{j,t},$$

where $g_{j,t}$ are government expenditures spent on home goods in country j. Note that we assume that the government spends only on domestic goods.

Labor market. We assume that wages are sticky and we ration the labor market uniformly across households by imposing that they work the same amount $n_{i,j,t} = n_{jt}$ for $i = s, b$. This assumption simplifies the analysis because it removes the possibility of poor households to increase their labor supply in response to a bad shock. Not much changes if we relax this assumption, except that we loose some tractability. See Midrigan and Philippon (2010) for a discussion. Each household supplies labor at the prevailing wage and receives wage income net of taxes $(1-\tau_{j,t})\, w_{j,t} n_{j,t}$. They also receive transfers from the government $T_{j,t}$.

Borrowing, lending and budget constraints. Let $b_{j,t}$ be the amount borrowed by impatient households. The budget constraint of these households in country j is:

$$\frac{b_{j,t}}{1+r} + (1-\tau_{j,t})\, w_{j,t} n_{j,t} + T_{j,t} = x_{b,j,t} + b_{j,t-1}, \tag{1}$$

where $x_{b,j,t} \equiv p_{j,t}^h c_{b,j,t}^h + p_t^f c_{b,t}^f$ is spending, as defined above, $b_{j,t}$ is the face value of the private debt issued at t and due at $t+1$, and r_t is the nominal rate between$t$ and $t+1$. In this section where we do not analyze

possible segmentation of financial markets, so r_t is common to all countries in the monetary union. There is a borrowing limit at any point in time

$$b_{j,t} \leq \bar{b}_{j,t}. \tag{2}$$

Savers save at the same nominal rate i_t and their budget constraint is:

$$s_{j,t-1} + (1 - \tau_{j,t}) w_{j,t} n_{j,t} + T_{j,t} = x_{s,j,t} + \frac{s_{j,t}}{1 + r_t}, \tag{3}$$

so their Euler equation is

$$\frac{1}{x_{s,j,t}} = \mathbb{E}_t \left[\frac{\beta (1 + r_t)}{x_{s,j,t+1}} \right]. \tag{4}$$

We will assume that monetary policy at the level of the monetary union is such that $\beta (1 + r_t) = 1$, so savers maintain a constant spending profile as long as there are no shocks. This assumption is convenient but it is not important. What is important, however, is the assumption that the interest rate is the same in all islands. The government budget constraint is

$$\frac{b^g_{j,t}}{1 + r} + \tau_{j,t} w_{j,t} n_{j,t} = p^h_{j,t} g_{j,t} + T_{j,t} + b^g_{j,t-1}, \tag{5}$$

where $b^g_{j,t}$ is public debt issued by government j at time t. We define nominal domestic product as

$$y_{j,t} \equiv p^h_{j,t} n_{j,t}$$

Nominal exports are $\bar{x}_f$, nominal imports are $(1 - \chi_j) p^f_{j,t} c^f_{s,j,t} + \chi_j p^f_{j,t} c^f_{b,j,t}$ since the government does not buy imported goods. So net exports are:

$$e_{j,t} = \bar{x}_f - (1 - \chi_{j,}) p^f_{j,t} c^f_{s,j,t} - \chi_j p^f_{j,t} c^f_{b,j,t}. \tag{6}$$

The net foreign asset position of the country is:

$$a_{j,t} \equiv (1 - \chi_j) s_{j,t} - \chi_j b_{j,t} - b^g_{j,t} \tag{7}$$

The closed economy corresponds to $a = 0$ and endogenous interest rate r. The small open region corresponds to exogenous i and endogenous a.

1.2 Nominal dynamics

We first analyze the nominal dynamics of the model before assuming a specific wage rigidity and real dynamics. We consider a sequence of shocks on the borrowing limit of the impatient households $\bar{b}_{j,1}, \bar{b}_{j,2}, ...$ and we look for decision rules for the savers $\{s_{j,t}\}_{t=1,2...}$ and the other variables of the model, $y_{j,t}$, $p^h_{j,t}$, etc. Note that the model is not stationary, since savings of patient households $\{s_t\}_{t=1,2...}$ never come back to any steady state. Importantly, we assume that the sequence of shocks on $\bar{b}_{j,t}$ in country j is a random walk: $\mathbb{E}_t\left[\bar{b}_{j,t+1}\right] = \bar{b}_{j,t}$, and that the shocks are small enough that impatient households find it optimal to set $b_{j,t} = \bar{b}_{j,t}$ at all times. This means that $b_{j,t}$ is effectively exogenous.

It will be convenient to define disposable income, after tax and transfers but before interest payments, as

$$\tilde{y}_{j,t} \equiv (1 - \tau_{j,t})\, y_{j,t} + T_{j,t}.$$

With this notation, we can write the budget constraint of the impatient agent as

$$x_{b,j,t} = \frac{b_{j,t}}{1+r} + \tilde{y}_{j,t} - b_{j,t-1},$$

and similarly for the savers $x_{s,j,t} = s_{j,t-1} + \tilde{y}_{j,t} - \frac{s_{j,t}}{1+r}$. The first equilibrium condition can simply be obtained by combining market clearing at time t with the budget constraints of the borrowers, the savers, and the government:

$$(1-\alpha_j)\,\tilde{y}_{j,t} = \chi_j \alpha_j \left(\frac{b_{j,t}}{1+r} - b_{j,t-1}\right) - (1-\chi_j)\,\alpha_j \left(\frac{s_{j,t}}{1+r} - s_{j,t-1}\right) + \frac{b^g_{j,t}}{1+r} - b^g_{j,t-1} + \bar{x}_{f,t} \tag{8}$$

This equation shows the four sources of nominal demand: impatient borrowers, patient savers, foreign demand and public expenditures. It holds even if interest rates vary over time and across agents.

The next step is to determine the dynamics of $x_{j,t}$ and $s_{j,t}$. This relies on the specific dynamics under permanent shocks. For borrowers, we already know that $\mathbb{E}_t\left[b_{j,t+1}\right] = b_{j,t}$. For savers, we conjecture (and we later verify) an equilibrium where $\mathbb{E}_t\left[s_{j,t+1}\right] = s_{j,t}$. For foreign demand, we also assume that $\mathbb{E}_t\left[\bar{x}_{f,t+1}\right] = \bar{x}_{f,t}$. FWe can rewrite the market clearing condition contained in equation (8) at time $t+1$, and use the conjecture that s_t and b_t are expected to remain at their current levels, we get:

$$(1-\alpha_j)\mathbb{E}_t\left[\tilde{y}_{j,t+1}\right] = \alpha_j \frac{r}{1+r}\left((1-\chi_j)\,s_{j,t} - \chi b_{j,t}\right) + \bar{x}_{f,t} + \mathbb{E}_t\left[\frac{b^g_{j,t+1}}{1+r} - b^g_{j,t}\right] \tag{9}$$

From time t+1 onward, the expected budget constraint of impatient agents at is $\mathbb{E}_t\left[x_{b,j,t+1}\right] = \mathbb{E}_t\left[\tilde{y}_{t+1}\right] - \frac{r}{1+r}b_{j,t}$. Similarly, for savers we have:

$$\mathbb{E}_t\left[x_{s,j,t+1}\right] = \mathbb{E}_t\left[\tilde{y}_{j,t+1}\right] + \frac{r}{1+r}s_{j,t}.$$

We can combine this last equation with the Euler equation of the savers to obtain the optimal path of saving for patient households:

$$s_{j,t} - s_{j,t-1} = \tilde{y}_{j,t} - \mathbb{E}_t\left[\tilde{y}_{j,t+1}\right] \tag{10}$$

The conditions says that savers optimally choose to keep their disposable wealth $\tilde{y}_{j,t} + s_{j,t-1}$ constant.

The three equilibirum conditions are then given by equations (8), (9) and (10). Clearly, our conjecture requires that disposable income follows a random walk: for all $h > 1$, we need to verify that $\mathbb{E}_t\left[\tilde{y}_{j,t+h}\right] = \mathbb{E}_t\left[\tilde{y}_{j,t+1}\right]$. We assume that government debt also follows a random walk, namely: $\mathbb{E}_t\left[\frac{b^g_{j,t+1}}{1+r}\right] = \frac{b^g_{j,t}}{1+r}$. As we will see, this does not constrain the government much. In particular, it does not prevent complete stabilization of nominal GDP.

Combining (8), (9) and (10) we can then find the optimal dynamics of saving as a function of the borrowing of the impatient agents as well as the borrowing the government:

$$s_{j,t} - s_{j,t-1} = \frac{\alpha_j\chi_j}{1-\alpha_j\chi_j}\left(b_{j,t} - b_{j,t-1}\right) + \frac{1}{1-\alpha_j\chi_j}\left(b^g_{j,t} - b^g_{j,t-1}\right) \tag{11}$$

This shows that saving of the patient inherits the dynamics of total borrowing of impatient agents and of the government. The reason is that borrowing dynamics affects total spending and therefore nominal income dynamics to which patient agents react optimally by changing their saving. Both the share of impatient agents χ_j and the share of home goods in consumption α_j affect the size of this reaction. The reason is that for a given shock on the borrowing limit, the impact on nominal spending and therefore nominal income will be larger if the share of impatient is larger and the economy is more closed. Given that we assume that government expenditures are spent entirely on domestic goods, openness is not as important for the impact of the change in government borrowing which is also the change in nominal government spending net of tax receipts.

For GDP, we show in the Appendix that

$$\Delta\left[\left(1-\tau_{j,t}\right)y_{j,t}\right]=\frac{1}{1-\alpha_j\chi_j}\left(\alpha_j\chi_j\left(\Delta\left[\frac{b_{j,t}}{1+r}\right]-\Delta\left[b_{j,t-1}\right]\right)+\Delta\left[\frac{b^g_{j,t}}{1+r}\right]-\Delta\left[b^g_{j,t-1}\right]\right)-\Delta\left[T_{j,t}\right]+\frac{\Delta\left[\bar{x}_{f,t}\right]}{1-\alpha_j} \tag{12}$$

where Δ denote first differences, i.e., $\Delta\left[y_{j,t}\right]=y_{j,t}-y_{j,t-1}$. The fact that changes in transfers enter negatively reflect the fact that they have a smaller impact on output than direct spending. This is because transfers can be saved by the patient agents and also because g is assumed to have 100% home bias. The instantaneous multiplier from private debt (measured in current period currency, so dropping the $\frac{1}{1+r}$ term) is $\frac{1}{1-\tau_j}\frac{\alpha_j\chi_j}{1-\alpha_j\chi_j}$. Assuming constant tax rates and constant levels of transfers, the multiplier for government debt is $\frac{1}{1-\tau_j}\frac{1}{1-\alpha_j\chi_j}$. The GDP multiplier for government spending is $\frac{1}{1-\alpha_j\chi_j}$ since it does not take into account the impact of spending on GDP and therefore on government revenues.

Aggregate nominal expenditures is given by $X_{j,t}\equiv\chi_j x_{b,t}+(1-\chi_j)x_{s,t}$, the sum of expenditures by impatient and patient households. It can be shown that with constant interest rates and foreign demand, optimal saving by the patient households allows their nominal expenditures to be constant over time so that the change in aggregate nominal expenditures is entirely driven by expenditures of the impatient households. Patient households can perfectly smooth their consumption in the case of constant interest rates and foreign demand because changes in the borrowing constraints of the impatients or in the public debt have no effect on their permanent income. Shocks on foreign demand affect the consumption of the patient households because they affect their permanent income. Hence, the change in aggregate consumption is given by the movements that affect the consumption of impatient agents (their borrowing constraint and public borrowing) and those that affect the consumption of the patient agents (the foreign demand):

$$\Delta X_{j,t}=\frac{\chi_j}{1-\alpha_j\chi_j}\left[\Delta\left(\frac{b_{j,t}+b^g_{j,t}}{1+r}\right)-\Delta\left(b_{j,t-1}+b^g_{j,t-1}\right)\right]+\frac{\left(1-\chi_j\right)\Delta\left[\bar{x}_{f,t}\right]}{1-\alpha_j} \tag{13}$$

1.3 Simple Government Policy Functions

We now turn to the policy function of the government. Our first goal is to describe the actual policy, not to compute the optimal one. In the model, fluctuations are driven by changes in nominal demand, themselves driven by leveraging and deleveraging of impatient households. We seek to build intuition using simple policy rules first, assuming constant foreign demand ($\Delta\left[\bar{x}_{f,t}\right]=0$). We therefore consider a rule of partial stabilization

$$b^g_{j,t}-b^g_{j,t-1}=-\gamma_j\alpha_j\chi_j\left(b_{j,t}-b_{j,t-1}\right), \tag{14}$$

with $\gamma_j < 1$. From equation (11), we then get

$$s_{j,t} - s_{j,t-1} = (1-\gamma_j)\frac{\alpha_j\chi_j}{1-\alpha_j\chi_j}\left(b_{j,t} - b_{j,t-1}\right). \tag{15}$$

Hence, the profile of nominal GDP in a more closed economy, with a larger share of impatient borrowers, with a less countercyclical public debt profile and higher income tax levels is more sensitive to shocks on borrowing constraints. We see that perfect stabilization of $s_{j,t}$ is theoretically possible by choosing $\gamma_j = 1$. In the Appendix, we can check that this rule also implies a constant disposable income. From the budget constraint of the government,

$$p^h_{j,t}g_{j,t} + T_{j,t} - \tau_{j,t}y_{j,t} = \frac{b^g_{j,t}}{1+r} - b^g_{j,t-1},$$

this policy also implies a path for nominal primary deficits. For many reasons, complete nominal stabilization is not actually feasible, even if it were optimal, which it needs not be in this model. In our application, we will look at actual policy. For GDP growth, this rule implies

$$y_{j,t} - y_{j,t-1} = \frac{1-\gamma_j}{1-\tau_j}\frac{\alpha_j\chi_j}{1-\alpha_j\chi_j}\left[\frac{b_{j,t} - b_{j,t-1}}{1+r} - (b_{j,t-1} - b_{j,t-2})\right] - \frac{T_{j,t} - T_{j,t-1}}{1-\tau_j}.$$

1.4 Foreign Assets and Exports

Note that combining (15) into the first difference of (7), we can get the evolution of the net foreign asset position of the country as a function of the borrowing of impatient agents and of the government:

$$a_{j,t} - a_{j,t-1} = -\frac{(1-\alpha_j)\chi_j}{1-\alpha_j\chi_j}\left(b_{j,t} - b_{j,t-1} + b^g_{j,t} - b^g_{j,t-1}\right) \tag{16}$$

An increase in borrowing by impatient agents or by the government deteriorates the net foreign asset position of the country, and the impact is stronger if there are more impatient types. If the government follows the simple rule (14) we can get:

$$a_{j,t} - a_{j,t-1} = -\left(1-\alpha_j\chi_j\gamma_j\right)\frac{\chi_j(1-\alpha_j)}{1-\alpha_j\chi_j}\left(b_{j,t} - b_{j,t-1}\right)$$

An increase in borrowing by impatient agents deteriorates the net foreign asset position of the country, but this deterioration is muted if the government conducts an active countercyclical fiscal policy with a high γ_j.

Notice, however, that even when $\gamma_j = 1$, so that nominal GDP is perfectly stabilized, the net foreign position is not constant.

The evolution of net exports is given by:

$$e_{j,t} - e_{j,t-1} = -\frac{\chi_j (1-\alpha_j)}{1-\alpha_j \chi_j} \left[\frac{\Delta b_{j,t}}{1+r} - \Delta b_{j,t-1} + \frac{\Delta b^g_{j,t}}{1+r} - \Delta b^g_{j,t-1} \right] \tag{17}$$

With the government rule of equation (14) we can get:

$$e_{j,t} - e_{j,t-1} = -(1-\alpha_j \chi_j \gamma_j) \frac{\chi_j (1-\alpha_j)}{1-\alpha_j \chi_j} \left[\frac{b_{j,t} - b_{j,t-1}}{1+r} - (b_{j,t-1} - b_{j,t-2}) \right] \tag{18}$$

so that net exports decrease with borrowing of impatient agents even if the government conducts an active countercyclical fiscal policy with a high γ_j.

1.5 Employment dynamics

The system above completely pins down the dynamics of nominal GDP $y_{j,t}$. Employment is given by

$$n_{j,t} = \frac{y_{j,t}}{p^h_{j,t}}.$$

We need to specify the dynamics of inflation. Letting $\bar{n}(\tau)$ denote the natural rate of unemployment, we assume the following Phillips curve:

$$\frac{p^h_{j,t} - p^h_{j,t-1}}{p^h_{j,t-1}} = \kappa (n_{j,t} - \bar{n}(\tau)) \tag{19}$$

$$\frac{\left(p^h_{j,t}\right)^2}{p^h_{j,t-1}} + (\kappa \bar{n} - 1) p^h_{j,t} - \kappa y_{j,t} = 0$$

Defining $\Delta \equiv (\kappa \bar{n} - 1)^2 + 4\kappa \frac{y_{j,t}}{p^h_{j,t-1}}$, we find that

$$\frac{p^h_{j,t}}{p^h_{j,t-1}} = \frac{1 - \kappa \bar{n} + \sqrt{\Delta}}{2}$$

Note that if $\frac{y_{j,t}}{p^h_{j,t-1}} = \bar{n}$, then $\Delta = \kappa \bar{n} \kappa \bar{n} + 1 + 2\kappa \bar{n} = (\kappa \bar{n} + 1)^2$, and $\frac{p^h_{j,t}}{p^h_{j,t-1}} = 1$.

We also experiment with asymmetric wage rigidity where wages are more flexible upward (when the

output gap is positive) than downward (when the output gap is negative)[4]:

$$\frac{p^h_{j,t} - p^h_{j,t-1}}{p^h_{j,t-1}} = \kappa_d \left[\frac{y_{j,t}}{p^h_{j,t-1}\bar{n}(\tau)} - 1 \right] \; if \; y_{j,t} < p^h_{j,t-1}\bar{n}(\tau) \tag{20}$$
$$\frac{p^h_{j,t} - p^h_{j,t-1}}{p^h_{j,t-1}} = \kappa_u \left[\frac{y_{j,t}}{p^h_{j,t-1}\bar{n}(\tau)} - 1 \right] \; if \; y_{j,t} > p^h_{j,t-1}\bar{n}(\tau)$$

where $\kappa_d < \kappa_u$.

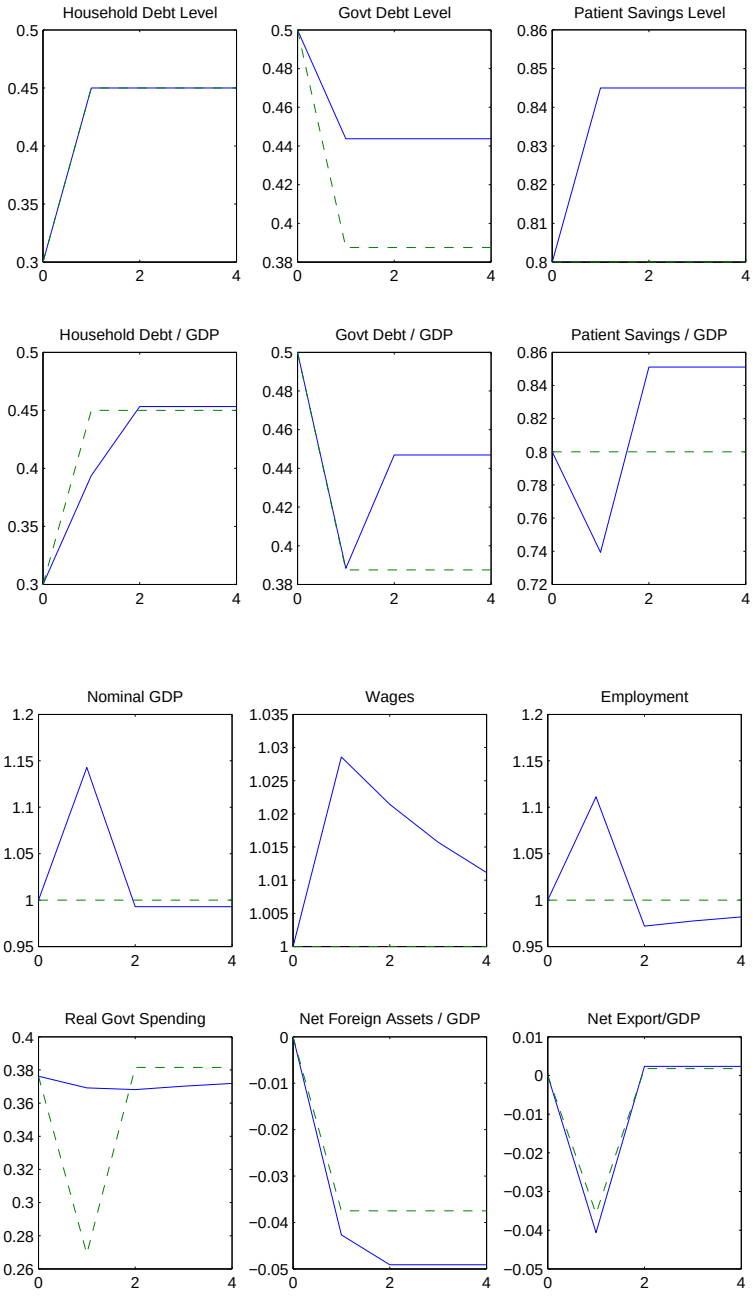
1.6 Simulation of a private credit shock

We first present in Figure (3) the simple impulse reaction functions that illustrate the qualitative impact of a positive shock (50% increase) on the borrowing constraint on both nominal and real variables. We set transfers to zero in this exercise. We compare two government policies: 1) the blue thick line is one where where the government partly stabilizes the shock on private debt with a change in public debt ($\gamma = 0.5$); 2) the green dashed line is one where the government debt reaction is such that patient saving and therefore nominal GDP is fully stabilized ($\gamma = 1$).

The other parameters are: $\alpha = 0.5, \chi = 0.5, i = 0.05, \kappa = 0.2, \tau = 0.4$. Prices, wages and employment are normalized to unity at time $t = 0$. The debt to income ratio is set at 60% for impatient households at time $t = 0$, so that the household debt to income ratio is 30%. The government debt to GDP ratio is set at 50% and the net foreign asset position over GDP is set at zero at time $t = 0$. With imperfect fiscal stabilization, the increase in borrowing by the impatient agents generate an increase in saving by the patient savers, a temporary increase in both nominal and real GDP (or employment in the later case) and a deterioration of the net foreign position of the country. Because GDP is stabilized in the case of counter-cyclical fiscal policy, the ratio of household debt to GDP ratio actually increases initially more than without countercyclical fiscal policy. The shock generates a short term spending/consumption boom.

[4]For empirical evidence on downward nominal wage rigidity, see for example, Schmitt-Grohe and Uribe (2012)on periphery countries in Europe.

Figure 3: Impulse reaction functions: an increase in the borrowing constraint



2 Quantitative Experiments

2.1 Experiment #1: Private Leverage

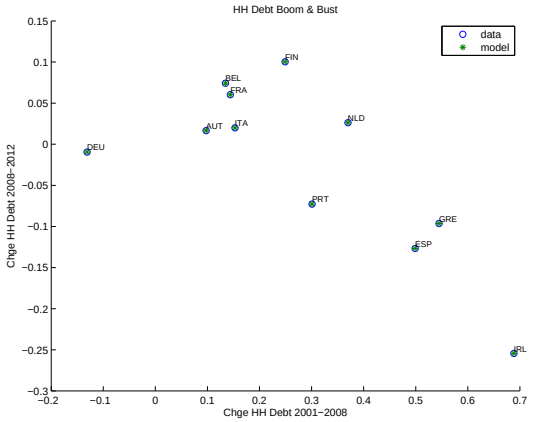
We next analyze a cross-sectional experiment on private leverage to compare the model predictions and the data. We describe the sources of the cross-sectional and aggregate data we use in the Appendix. We use data for 11 Eurozone countries: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Netherlands and Portugal and calibrate the shock on the change in household debt by the observed data. The parameters that serve in the simulations are given below.

Table 1: Parameters

Parameter Name		*Value*
Annual Discount Factor	β	0.95
Domestic share	α	0.75
Share of impatient borrowers	χ	0.5
Government rule on public debt	γ	0.3
Tax rate	τ	0.4
Transfer rate	T/y	0.2
Symmetric Phillips parameter	κ	0.2
Asymmetric Phillips parameter	κ_d	0.15
Asymmetric Phillips parameters	κ_u	0.3

For the domestic share of consumption α, we rely on the paper by Bussiere et al. (2011) who compute the total import content of expenditure components, including the value of indirect imports. For consumption expenditures and for our sample our countries the average in 2005 (the latest date in their study) is 27.3%. Hence, we choose $\alpha = 0.75$. The government rule on public debt is based on a the correlation coefficient between changes in household debt and public debt in our data and sample of countries. The tax rate is the average for government revenues divided by GDP for the sample. This is around 40%. We do the same thing for transfers which is around 20% of GDP for our sample of countries.

Figure 4: Simulations of Boom/Bust in Household Debt



We run the experiment of simulating the impact of the following path for household debt:

- household leveraging up for 8 years between 2001 and 2008: the path of household debt $b_{j,t}$ for each country is given by observed household debt linearly spread between 2001 and 2008.
- household deleveraging for 5 years (2008-2012): the path of household debt $b_{j,t}$ for each country is given by observed household debt linearly spread between 2008 and 2012.

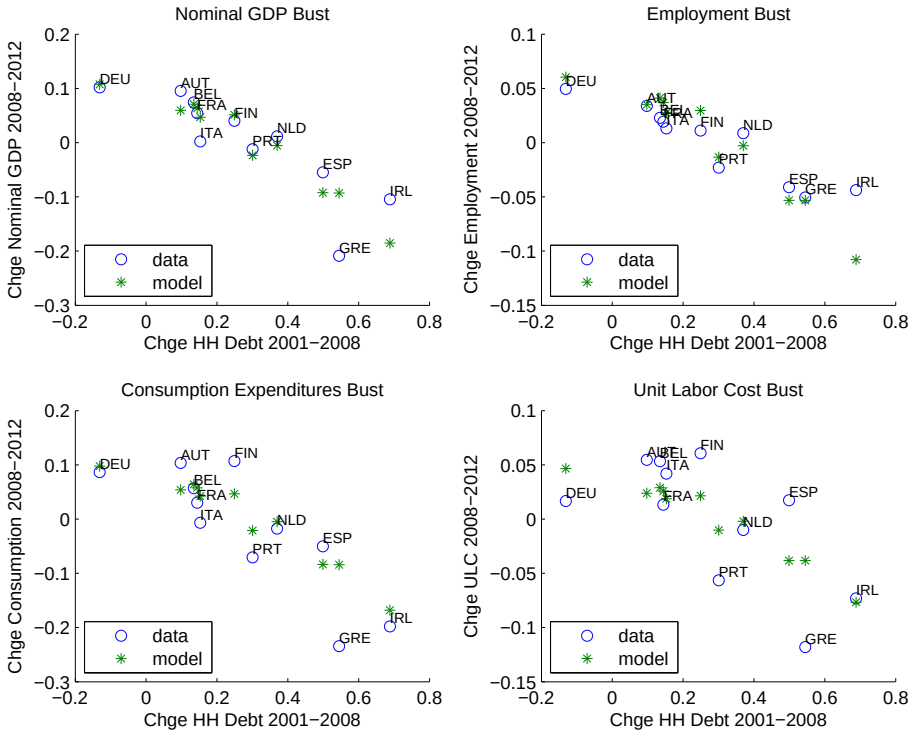
To transform observed aggregate household debt in the data into household debt $b_{j,t}$ in the model which is debt per impatient household (with share ψ), we take the household to benchmark income (see appendix for how we compute this income) ratio for each country and then multiply it by the share of impatient in the economy ψ.

All countries in the simulation are assumed to start with zero net foreign assets in 2001. Wages and therefore prices in the model are initialized to the unit labor costs observed in 2001. Nominal GDP as well as public debt are also initialized to their observed levels in 2001. Employment in the model is initialized to real GDP in the data in 2001. Exports are constant and set to what the resource constraint (8) predicts in steady state.

Figure 4 presents the driving variable of our model, the change in household debt in the 2001-2008 period and in the 2008-2012 period.

We simulate the dynamics predicted from our model for each country $j = 1..11$ and year $t = 1..13$. In the figures below we plot the cross sectional comparison of the model and the observed data. We describe in more detail in the appendix how we rebase the observed data to make it comparable to the model predictions.

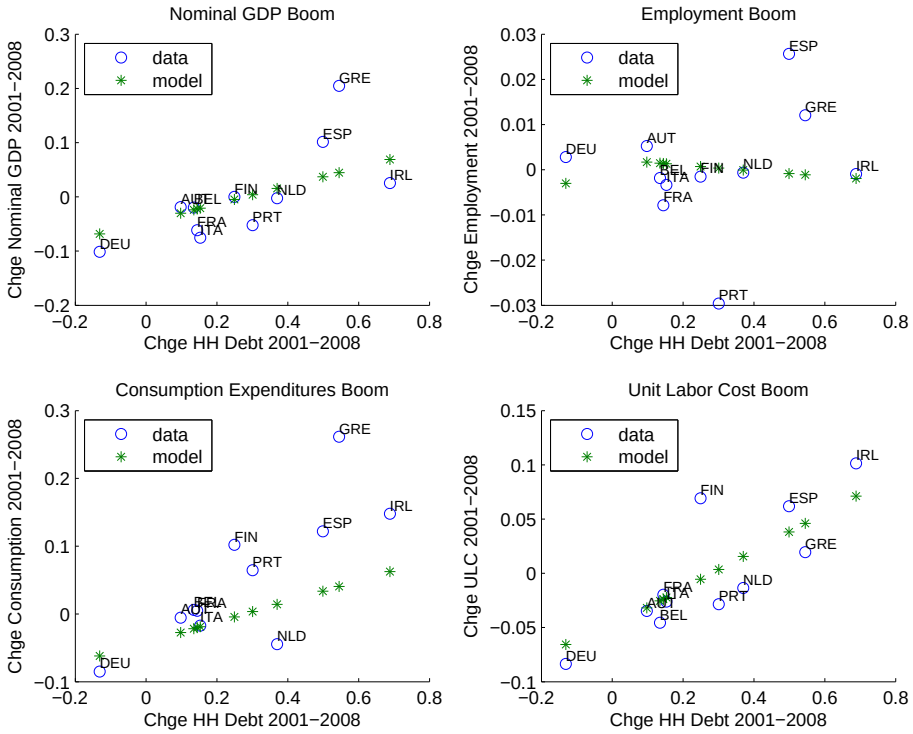
Figure 5: Simulations of the Bust with Shocks to $\bar{b}$



Our main interest is in matching figure 1. This is done in Figure 5. The fit of the model is already quite good in all dimensions. Countries that experienced the largest increase in household debt in the boom period also experienced the largest fall in nominal GDP, employment, consumption and to some extent wages in the bust period. For Greece, the model under predicts the extent of the fall in nominal GDP and consumption. It over predicts the employment fall in the bust for Ireland.

We can also test the prediction in the boom. Those countries with the highest increase in household debt benefited from higher nominal GDP, consumption and wages. The increase in nominal GDP during the boom is under predicted for Greece. The fact that wages are less rigid upward in the boom implies that the employment growth is not correlated to household debt in the boom. This is not the case either in the data.

Figure 6: Simulations of the Boom with Shocks to $\bar{b}$



2.2 Experiment #2: adding Fiscal Policy

In this experiment, we add fiscal policy to the dynamics of private debt described above. We use the actual paths for the policy variables g and T. We assume that the tax rate is constant: $\tau_{j,t} = \tau_j$. In the Appendix we show that nominal output has the recursive form:

$$\left(1 + \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \tau_j\right) \Delta \left[y_{j,t}\right] = \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \left(\Delta \left[\frac{b_{j,t}}{1+r}\right] - \Delta \left[b_{j,t-1}\right]\right) + \frac{1}{1 - \alpha_j \chi_j} \Delta \left[p^h_{j,t} g_{j,t}\right] + \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \Delta \left[T_{j,t}\right] + \frac{\Delta \left[\bar{x}_{f,t}\right]}{1 - \alpha_j}$$

Using this recursive equation together with the equilibrium conditions of the model, we construct a panel of simulated data for all the variables of interest.

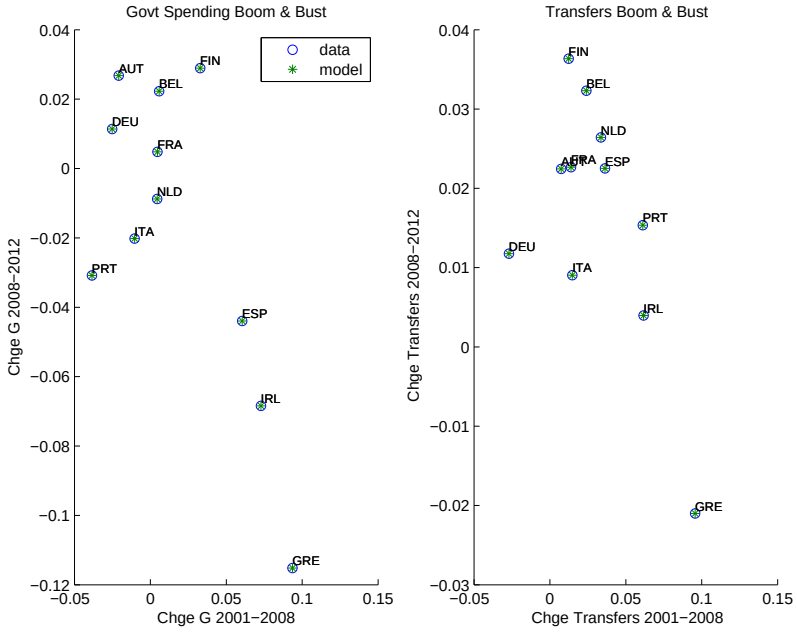
We run the experiment of simulating the impact of the following path for household debt:

- household leveraging and deleveraging, as described in the previous section.
- government spending and transfers between 2001 and 2008: the path of for each country is given by observed government spending and transfers linearly spread between 2001 and 2008.

- government spending and transfers between 2008 and 2012: the path of for each country is given by observed government spending and transfers linearly spread between 2008 and 2012.

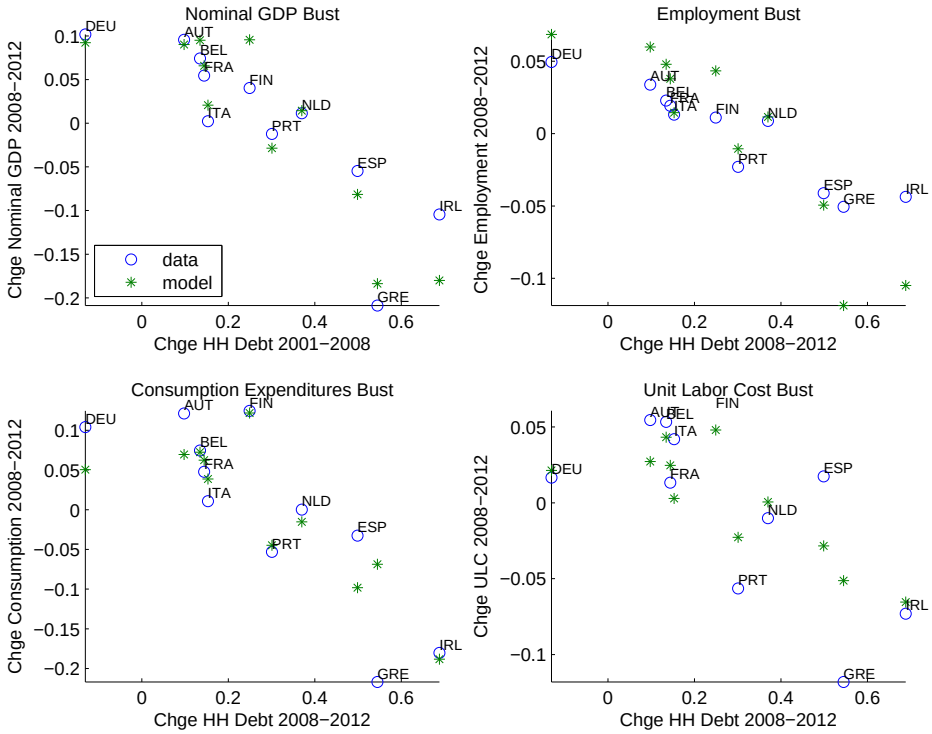
In the same way as before with Figure 4, Figure 7 presents the additional driving variables of our model, the change in spending and transfers during the 2001-2008 period and during the 2008-2012 period. By construction, they match exactly their empirical counterparts.

Figure 7: Government spending and transfers in boom and bust



We simulate the dynamics predicted from our model for each country $j = 1..11$ and year $t = 1..13$. In the figures below we plot the cross sectional comparison of the model and the observed data. We describe in more detail in the appendix how we rebase the observed data to make it comparable to the model predictions.

Figure 8: Simulations of the Bust with Shocks to b, g, T



Our main interest is in matching figure 1. This is done in Figure 8. The fit of the model improves significantly. For instance, when we compare GDP for Spain and Greece, we see that adding fiscal variables improves the fit.

Figure 9 tests the predictions in the boom. We have already seen that those countries with the highest increase in household debt benefited from higher nominal GDP, consumption and wages. Once again, we see that adding fiscal variables improves significantly the fit of the model. Without fiscal variables, we had very little action on GDP and employment. With fiscal variables, the fit for GDP is much better.

Finally, and interestingly, we find that, once fiscal variables are taken into account, there is much less need for asymmetric wage rigidity. In fact, the parameters are now 0.7 and 0.75 for upward and downward rigidity.

There remain some important discrepancies that future work should address. The main features that are still missing from the model are:

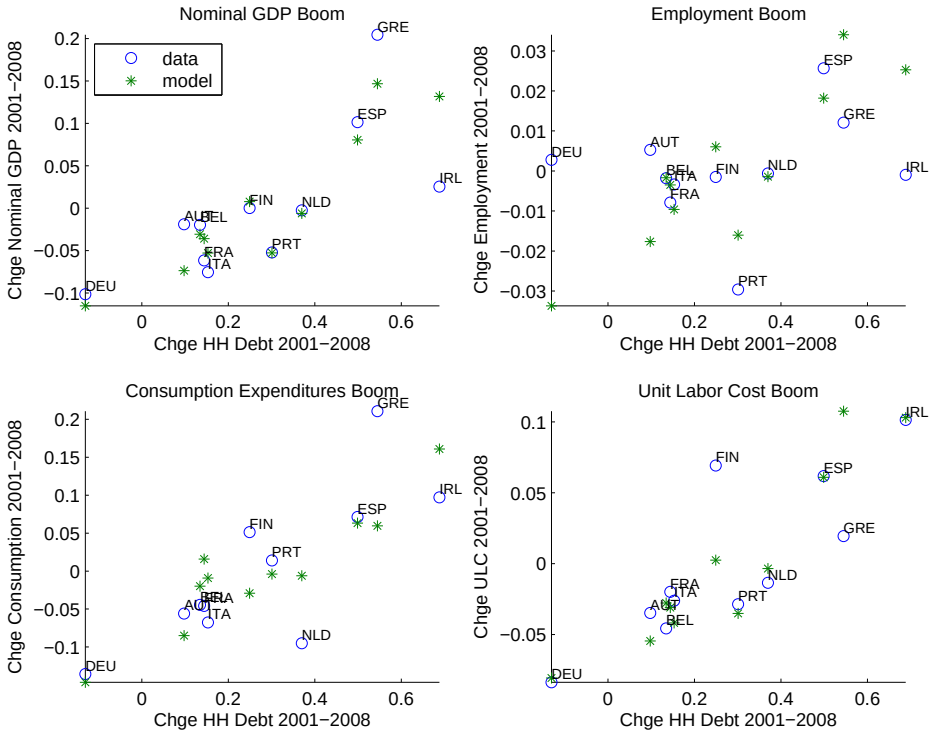
- Consumption spending in Greece during the boom is higher than predicted. This might not be surprising given what we have discovered ex-post.

- Employment bust is not as bad in Greece as predicted, while the drop of unit labor cost is higher. This might signal the need to allow for contingent wage rigidity.

- Labor market outcomes for Germany and Portugal in the boom. Clearly, the performance of labor markets in the boom is better than predicted for Germany and worse for Portugal. This is consistent with the idea that the nature of spending and welfare cuts matters for labor supply decisions, as predicted in Neoclassical models. These are absent from this simulation.

- Throughout the simulations, Ireland's GDP is more stable than predicted. This can come from two reasons. First, there is a mundane measurement issue, because the recession starts earlier in Ireland. There is a sharp drop in GDP from 2007 to 2008. Second, Ireland is more open that other countries. We should therefore use a country specific α.

Figure 9: Simulations of the Boom with Shocks to b, g, T



2.3 Experiment 3: Sudden Stops (work in progress)

We model the possibility of a sudden stop as a siutaion where capital markets becomes segmented and where interest rates differ across countries of the euro zone because of soveriegn risk. Interest rates are stochastic and in the countries where they rise this affects the Euler equation of the savers.

3 Conclusion

To be completed.

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Appendix

A Model

A.1 Dynamics

Using the market clearing condition, and competition $p^h_{j,t} = w_{j,t}$, we get

$$y_{j,t} = \alpha_j \left(\chi_j x_{b,j,t} + (1-\chi_j) x_{s,j,t}\right) + \bar{x}_f + p^h_{j,t} g_{j,t}.$$

Nominal exports are $\bar{x}_f$, nominal imports are $(1-\chi_j) p^f_{j,t} c^f_{s,j,t} + \chi_j p^f_{j,t} c^f_{b,j,t}$ since the government does not buy imported goods. So net exports are:

$$e_{j,t} = \bar{x}_f - (1-\alpha_j)\left(\chi_j x_{b,j,t} + (1-\chi_j) x_{s,j,t}\right).$$

We can then write the system for *nominal variables* as

- $x_{b,j,t} = \frac{b_{j,t}}{1+r} + (1-\tau_{j,t}) y_{j,t} + T_{j,t} - b_{j,t-1}$ budget constraint of impatient
- $x_{s,j,t} = s_{j,t-1} + (1-\tau_{j,t}) y_{j,t} + T_{j,t} - \frac{s_{j,t}}{1+r}$ budget constraint of patient
- $y_{j,t} = \alpha_j \left(\chi_j x_{b,j,t} + (1-\chi_j) x_{s,j,t}\right) + \bar{x}_f + p^h_{j,t} g_{j,t}$ market clearing
- $x_{s,j,t} = \mathbb{E}_t\left[x_{s,j,t+1}\right]$ Euler equation of patient (second order approximation, but in fact we can show that x_s is constant)
- $p^h_{j,t} g_{j,t} + T_{j,t} - \tau_{j,t} y_{j,t} = \frac{b^g_{j,t}}{1+r} - b^g_{j,t-1}$ Government budget constraint
- $e_{j,t} = \frac{1}{\alpha_j}\left(\bar{x}_f - (1-\alpha_j)\left(y_{j,t} - p^h_{j,t} g_{j,t}\right)\right)$

There are then three equilibrium conditions, which we can write using the after-tax income $\tilde{y}_{j,t} \equiv (1-\tau_{j,t}) y_{j,t} + T_{j,t}$ as:

- $(1-\alpha_j)\tilde{y}_{j,t} = \chi_j \alpha_j \left(\frac{b_{j,t}}{1+r} - b_{j,t-1}\right) - (1-\chi_j)\alpha_j \left(\frac{s_{j,t}}{1+r} - s_{j,t-1}\right) + \frac{b^g_{j,t}}{1+r} - b^g_{j,t-1} + \bar{x}_f$: always true.
- $s_{j,t} - s_{j,t-1} = \tilde{y}_{j,t} - \mathbb{E}_t\left[\tilde{y}_{j,t+1}\right]$: requires $\mathbb{E}_t\left[s_{j,t+1}\right] = s_{j,t}$
- $(1-\alpha_j)\mathbb{E}_t\left[\tilde{y}_{j,t+1}\right] = \alpha_j \frac{r}{1+r}\left((1-\chi_j) s_{j,t} - \chi b_{j,t}\right) + \bar{x}_f + \mathbb{E}_t\left[\frac{b^g_{j,t+1}}{1+r} - b^g_{j,t}\right]$: requires also $\mathbb{E}_t\left[b_{j,t+1}\right] = b_{j,t}$.

We can combine the last two conditions to get the dynamics of after tax and transfer nominal income as a function of changes in private and public debt:

$$(1-\alpha_j)\left(\tilde{y}_{j,t} - \mathbb{E}_t\left[\tilde{y}_{j,t+1}\right]\right) = \alpha_j\left(\chi_j\left(b_{j,t} - b_{j,t-1}\right) - (1-\chi_j)\left(s_{j,t} - s_{j,t-1}\right)\right) + b^g_{j,t} - b^g_{j,t-1} + \mathbb{E}_t\left[\frac{b^g_{j,t+1} - b^g_{j,t}}{1+r}\right]$$

We then conjecture random walks for the variables of interest. The two key equations are then disposable income

$$(1-\alpha_j)\tilde{y}_{j,t} = \chi_j \alpha_j \left(\frac{b_{j,t}}{1+r} - b_{j,t-1}\right) - (1-\chi_j)\alpha_j \left(\frac{s_{j,t}}{1+r} - s_{j,t-1}\right) + \bar{x}_f + \frac{b^g_{j,t}}{1+r} - b^g_{j,t-1},$$

and endogenous savings

$$s_{j,t} - s_{j,t-1} = \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \left(b_{j,t} - b_{j,t-1} \right) + \frac{1}{1 - \alpha_j \chi_j} \left(b^g_{j,t} - b^g_{j,t-1} \right),$$

which we can also write

$$\alpha_j \chi_j \left(b_{j,t} - b_{j,t-1} \right) + b^g_{j,t} - b^g_{j,t-1} = \left(1 - \alpha_j \chi_j \right) \left(s_{j,t} - s_{j,t-1} \right).$$

It will often be useful to obtain a recursive equation for nominal GDP. Taking the first difference of the disposable income equation we get

$$\begin{aligned}
\left(1-\alpha_j\right)\left(\tilde{y}_{j,t}-\tilde{y}_{j,t-1}\right) &= \chi_j\alpha_j\left(\frac{b_{j,t}}{1+r}-b_{j,t-1}-\left(\frac{b_{j,t-1}}{1+r}-b_{j,t-2}\right)\right) \\
&\quad -\left(1-\chi_j\right)\alpha_j\left(\frac{s_{j,t}}{1+r}-s_{j,t-1}-\left(\frac{s_{j,t-1}}{1+r}-s_{j,t-2}\right)\right)+\frac{b^g_{j,t}}{1+r}-b^g_{j,t-1}-\left(\frac{b^g_{j,t-1}}{1+r}-b^g_{j,t-2}\right) \\
&= \chi_j\alpha_j\left(\frac{b_{j,t}-b_{j,t-1}}{1+r}-\left(b_{j,t-1}-b_{j,t-2}\right)\right)-\left(1-\chi_j\right)\alpha_j\left(\frac{s_{j,t}-s_{j,t-1}}{1+r}-\left(s_{j,t-1}-s_{j,t-2}\right)\right) \\
&\quad +\frac{b^g_{j,t}-b^g_{j,t-1}}{1+r}-\left(b^g_{j,t-1}-b^g_{j,t-2}\right) \\
&= \left(1-\alpha_j\chi_j\right)\left(\frac{s_{j,t}-s_{j,t-1}}{1+r}-\left(s_{j,t-1}-s_{j,t-2}\right)\right)-\left(1-\chi_j\right)\alpha_j\left(\frac{s_{j,t}-s_{j,t-1}}{1+r}-\left(s_{j,t-1}-s_{j,t-2}\right)\right) \\
&= \left(1-\alpha_j\right)\left(\frac{s_{j,t}-s_{j,t-1}}{1+r}-\left(s_{j,t-1}-s_{j,t-2}\right)\right)
\end{aligned}$$

so

$$\tilde{y}_{j,t}-\tilde{y}_{j,t-1}=\frac{1}{1-\alpha_j\chi_j}\left(\chi_j\alpha_j\left(\frac{b_{j,t}-b_{j,t-1}}{1+r}-\left(b_{j,t-1}-b_{j,t-2}\right)\right)+\frac{b^g_{j,t}-b^g_{j,t-1}}{1+r}-\left(b^g_{j,t-1}-b^g_{j,t-2}\right)\right)$$

So for GDP we get

$$\left(1-\tau_{j,t}\right)y_{j,t}-\left(1-\tau_{j,t}\right)y_{j,t}=\frac{\chi_j\alpha_j\left(\frac{b_{j,t}-b_{j,t-1}}{1+r}-\left(b_{j,t-1}-b_{j,t-2}\right)\right)+\frac{b^g_{j,t}-b^g_{j,t-1}}{1+r}-\left(b^g_{j,t-1}-b^g_{j,t-2}\right)}{1-\alpha_j\chi_j}-\left(T_{j,t}-T_{j,t-1}\right)$$

The fact that changes in transfers enter negatively reflect the fact that they have a smaller impact on output than direct spending. This is because transfers can be saved by the patient agents.

A.2 Government policy and stabilization

From equation (11), we see that perfect stabilization of $s_{j,t}$ is theoretically possible by choosing the following rule:

$$b^g_{j,t} = b^g_{j,t-1} - \alpha_j \chi_j \left(b_{j,t} - b_{j,t-1} \right)$$

We can check that this implies a constant disposable income. We can check that this implies a constant disposable income. Replacing this rule into equation (8) and using the fact that $s_{j,t}$ is constant, we get

$$\begin{aligned}(1-\alpha_j)\,\tilde{y}_{j,t} &= \bar{x}_f + \frac{r}{1+r}\left((1-\chi_j)\,\alpha_j s_{j,t-1}\right)\\ &= \bar{x}_f + \frac{r}{1+r}\left((1-\chi_j)\,\alpha_j s_{j,t-2} - b^g_{j,t-2} - \alpha_j\chi_j b_{j,t-2}\right)\\ &= (1-\alpha_j)\,\tilde{y}_{j,t-1}.\end{aligned}$$

This rule therefore stabilizes the net of tax and transfer nominal GDP $(1-\tau_{j,t})\,y_{j,t}+T_{j,t}$, or disposable income.

If we further assume a constant τ_j, and a random walk for transfers such that $\mathbb{E}_t\left[T_{j,t+1}\right]=T_{j,t}$, then dynamics are such that shocks on the borrowing constraint of borrowers are muted by a factor γ_j, so that:

$$(1-\alpha_j)\,\tilde{y}_{j,t} = \chi_j\alpha_j\left(\frac{b_{j,t}}{1+r}-b_{j,t-1}\right)+(1-\chi_j)\,\alpha_j\left(s_{j,t-1}-\frac{s_{j,t}}{1+r}\right)+\bar{x}_f+\frac{b^g_{j,t}}{1+r}-b^g_{j,t-1}$$

and

$$\tilde{y}_{j,t}-\tilde{y}_{j,t-1} = (1-\gamma_j)\,\frac{\chi_j\alpha_j}{1-\alpha_j\chi_j}\left(\frac{b_{j,t}-b_{j,t-1}}{1+r}-\left(b_{j,t-1}-b_{j,t-2}\right)\right)$$

and

$$y_{j,t}-y_{j,t-1} = \frac{1-\gamma_j}{1-\tau_j}\frac{\alpha_j\chi_j}{1-\alpha_j\chi_j}\left[\frac{b_{j,t}-b_{j,t-1}}{1+r}-\left(b_{j,t-1}-b_{j,t-2}\right)\right]-\frac{T_{j,t}-T_{j,t-1}}{1-\tau_j}$$

and

$$\mathbb{E}_t\left[y_{j,t+1}\right]-y_{j,t} = -\frac{s_{j,t}-s_{j,t-1}}{1-\tau_j} = -\frac{1-\gamma_j}{1-\tau_j}\frac{\alpha_j\chi_j}{1-\alpha_j\chi_j}\left(b_{j,t}-b_{j,t-1}\right)$$

These two equations show the tendency of mean reversion in this model. For net foreign assets, we get

$$\begin{aligned}a_{j,t}-a_{j,t-1} &= (1-\chi_j)\left(s_{j,t}-s_{j,t-1}\right)-\chi_j\left(b_{j,t}-b_{j,t-1}\right)-\left(b^g_{j,t}-b^g_{j,t-1}\right)\\ &= -\frac{(1-\alpha_j)\,\chi_j}{1-\alpha_j\chi_j}\left(b_{j,t}-b_{j,t-1}+b^g_{j,t}-b^g_{j,t-1}\right)\end{aligned}$$

A.3 Fiscal Policy Experiment

Let us consider the dynamics of the economy for arbitrary paths for transfers and spending T and g. The equilibrium conditions are

- $s_{j,t}-s_{j,t-1}=\tilde{y}_{j,t}-\mathbb{E}_t\left[\tilde{y}_{j,t+1}\right]$
- $(1-\alpha_j)\mathbb{E}_t\left[\tilde{y}_{j,t+1}\right]=\alpha_j\frac{r}{1+r}\left((1-\chi_j)\,s_{j,t}-\chi b_{j,t}\right)+\bar{x}_f+\mathbb{E}_t\left[\frac{b^g_{j,t+1}}{1+r}-b^g_{j,t}\right]$
- $(1-\alpha_j)\,\tilde{y}_{j,t}=\chi_j\alpha_j\left(\frac{b_{j,t}}{1+r}-b_{j,t-1}\right)-(1-\chi_j)\,\alpha_j\left(\frac{s_{j,t}}{1+r}-s_{j,t-1}\right)+\frac{b^g_{j,t}}{1+r}-b^g_{j,t-1}+\bar{x}_f$
- $\frac{b^g_{j,t}}{1+r}+\tau_{j,t}y_{j,t}=p^h_{j,t}g_{j,t}+T_{j,t}+b^g_{j,t-1}$

Then

$$s_{j,t} - s_{j,t-1} = \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \left(b_{j,t} - b_{j,t-1} \right) + \frac{1}{1 - \alpha_j \chi_j} \left(b^g_{j,t} - b^g_{j,t-1} \right)$$

and

$$\Delta \left[(1 - \tau_{j,t}) \, y_{j,t} \right] = \frac{1}{1 - \alpha_j \chi_j} \left(\alpha_j \chi_j \left(\Delta \left[\frac{b_{j,t}}{1+r} \right] - \Delta \left[b_{j,t-1} \right] \right) + \Delta \left[\frac{b^g_{j,t}}{1+r} \right] - \Delta \left[b^g_{j,t-1} \right] \right) - \Delta \left[T_{j,t} \right]$$

From the government budget constraint, we have

$$\Delta \left[\frac{b_{j,t}}{1+r} \right] - \Delta \left[b^g_{j,t-1} \right] = \Delta \left[p^h_{j,t} g_{j,t} \right] + \Delta \left[T_{j,t} \right] - \Delta \left[\tau_{j,t} y_{j,t} \right]$$

therefore

$$\Delta \left[\left(1 + \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \tau_{j,t} \right) y_{j,t} \right] = \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \left(\Delta \left[\frac{b_{j,t}}{1+r} \right] - \Delta \left[b_{j,t-1} \right] \right) + \frac{1}{1 - \alpha_j \chi_j} \Delta \left[p^h_{j,t} g_{j,t} \right] + \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \Delta \left[T_{j,t} \right]$$

Assume that the tax rate is constant: $\tau_{j,t} = \tau_j$ then we get a recursive equation for nominal output

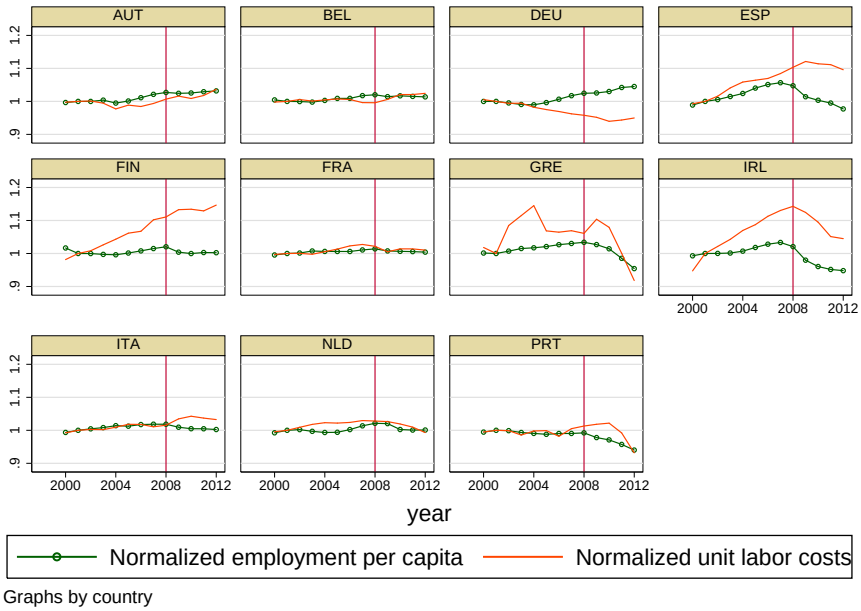
$$\left(1 + \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \tau_j \right) \Delta \left[y_{j,t} \right] = \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \left(\Delta \left[\frac{b_{j,t}}{1+r} \right] - \Delta \left[b_{j,t-1} \right] \right) + \frac{1}{1 - \alpha_j \chi_j} \Delta \left[p^h_{j,t} g_{j,t} \right] + \frac{\alpha_j \chi_j}{1 - \alpha_j \chi_j} \Delta \left[T_{j,t} \right]$$

B Data

All economic data (employment, population, GDP, consumption, government debt, expenditures...) comes from Eurostat. The data on household debt comes from the BIS which itself compiled the data from national central banks. Credit covers all loans and debt securities and comes from both domestic and foreign lenders. We had to exclude Luxembourg for which data is available only starting in 2005. We also excluded eurozone countries that joined 2007 and later. We are left with 11 countries: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Netherlands and Portugal.

In order to map the observed data into the model we rebase the data in the following manner. We construct a benchmark level of GDP for each country and year: it is the GDP the country would have experienced if it had the same growth rate as the whole eurozone during the period 2001-2007. Hence, we assume no difference in TFP growth. Starting in 2008 this benchmark growth rate is the average of the eurozone crisis, around 1%. We compute a benchmark in the same manner for consumption, government spending, transfers and unit labor costs. The normalized data is the ratio of the observed data to this benchmark level. This enables us therefore to interpret these as deviations from the benchmark levels for each data series we observe. For both the household debt and the government debt, the rebased levels are the ratios of debt to the benchmark levels of GDP. Aggregate variables (employment, GDP, consumption, transfers, government spending and taxes and transfers...) are analyzed either in per capita terms or in ratios of GDP. For employment per capita, we take the deviation with respect to 2001 with an index of 1 for that year. 2001 is the base year for consumption and unit labor costs (index 1 in 2001). The normalized data are given in figures 10 and11.

Figure 10: Normalized data for comparison with model: employment, unit labor costs, consumption and GDP



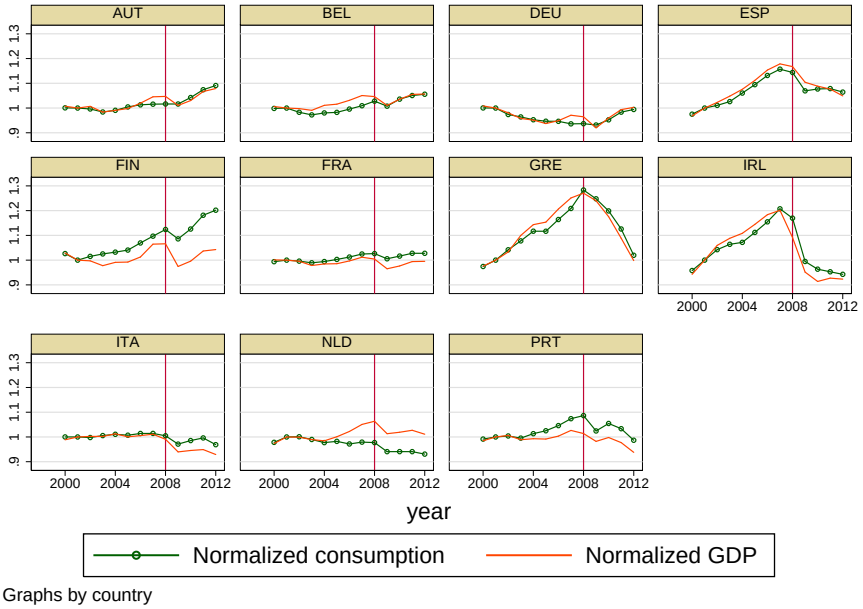


Figure 11: Normalized data for comparison with model: household and sovereign debt, govt. spending (adj. for bank recap) and social transfers

